Ohio Agricultural Experiment Station

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PLANS AND SUMMARY TABLES

OF THE EXPERIMENTS AT THE CENTRAL FARM, WOOSTER,

ON THE

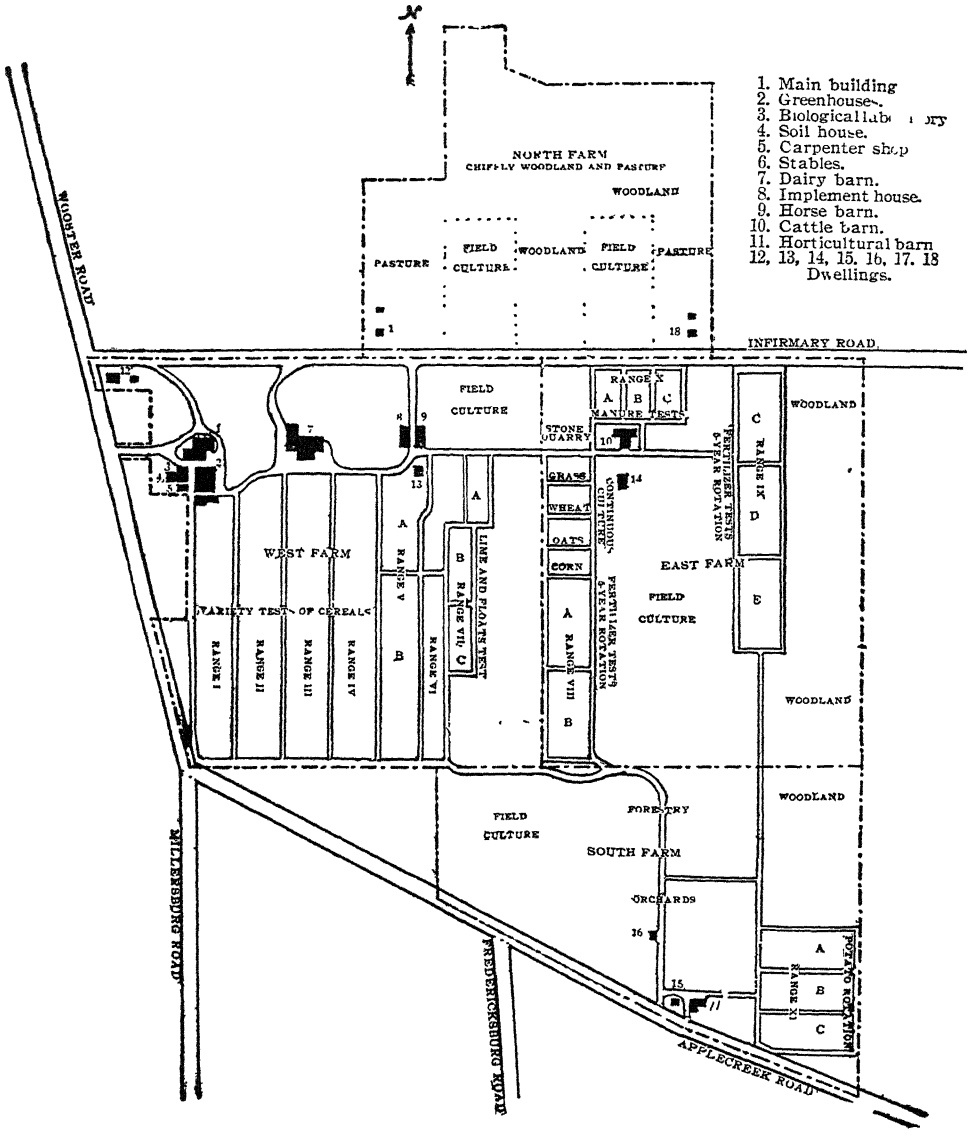
MAINTENANCE OF SOIL FERTILITY

ARRANGED FOR REFERENCE IN THE FIELD

ANNOUNCEMENT

The experiments reported in the following pages were begun in 1893, immediately after the removal of the Experiment Station to Wayne county. The general plan of this work and the results obtained up to that time are published in Bulletin 110, issued in December, 1899, (now out of print) and again in Bulletins 182, 183, and 184, reporting to the end of 1906. It now seems desirable to follow these general publications with an annual statement, giving as briefly as possible the new data obtained from each successive crop, and referring the reader to Bulletins 182 and 183 for more complete information respecting the nature of the soils under experiment and the general plan of the work, and to Bulletin 184 for the statistics of crop yields for the years 1894 to 1906, inclusive.

The results for 1907 are given in Circular No. 83, those for 1908 in Circular No. 92, those for 1909 in Circular No. 104, and those for 1910 in Circular No. 114.



The central farm, near Wooster

FERTILIZERS AND MANURE ON CROPS GROWN CONTINUOUSLY ON THE SAME LAND

Wheat, oats and corn, one acre (10 plots) each, have been grown in this experiment since 1894. The fertilizers are applied to Plots 2 and 8 in arbitrary quantities, while on Plots 3 and 9 the three fertilizing elements, nitrogen, phosphorus and potassium, are given in approximately the same ratio to each other in which they are found in the plant.

The applications to Plots 2 and 8 have in every case produced larger average yields than those to Plots 3 and 9, but this may in part be accounted for by the combined nitrogen which is carried to the soil in rain, thus enabling the crops grown on 2 and 8 to utilize larger quantities of the phosphorus and potassium given in the fertilizer than that required merely to balance the fertilizer nitrogen.

The manure applications on Plots 5 and 6 were intended to carry nitrogen in quantities equivalent to the applications on Plots 2 and 3 on the one hand and 8 and 9 on the other, estimating the manure to carry 10 pounds of nitrogen per ton, but actual analyses of manure made during recent years indicate that this estimate was too high for open yard manure, such as is used in these tests. The average application of phosphorus and potassium in the manure closely approximates the average given to the four fertilized plots.

In this test the corn and wheat show a rapid falling off in yield on the unfertilized land during recent years. The oats also show a reduction in yield, but not so great as that of the other crops.

It is much more difficult to control the weed growth in the wheat and oats grown continuously than where the same crops are grown in rotation, and it was necessary a few years ago to divide these tracts and fallow the two ends in alternate seasons in order to destroy the weeds. Latterly the entire plots have been cropped again.

Diagram I shows the arrangement of plots and plan of fertilizing in this experiment, and the general outcome is shown in Tables I and II, which give the yields by periods.

DIAGRAM I: PLAN OF FERTILIZING IN CONTINUOUS CULTURE

PLOTS ONE-TENTH ACRE

	Fertilizing materials in pounds per acre
Wheat	
1	None
2	Acid phos., 160; muriate potash, 100; nitrate soda, 120; dried blood, 50*
3	Acid phos., 45; muriate potash, 30; nitrate soda, 120; dried blood, 50*
4	None
5	Yard manure, 2½ tons
6	Yard manure, 5 tons
7	None
8	Acid phos., 160; muriate potash, 100; nitrate of soda, 280; dried blood, 50 *
9	Acid phos., 90; muriate potash, 60; nitrate of soda, 280; dried blood, 50**
10	None
Oats	
1	None
2	Acid phos., 160; muriate potash, 100; nitrate soda, 160
3	Acid phos., 55; muriate potash, 50; nitrate soda, 160
4	None
5	Yard manure, 2½ tons
6	Yard manure, 5 tons
7	None
8	Acid phos., 160; muriate potash, 100; nitrate soda, 320
9	Acid phos., 110; muriate potash, 100; nitrate soda, 320
10	None
Corn	
1	None
2	Acid phos., 160; muriate potash, 100; nitrate soda, 160
3	Acid phos., 60; muriate potash, 30; nitrate soda, 160
4	None
5	Yard manure, 2½ tons
6	Yard manure, 5 tons
7	None
8	Acid phos., 160; muriate potash, 100; nitrate soda, 320
9	Acid phos., 120; muriate potash, 60; nitrate soda, 320
10	None
	(South)

*120 pounds nitrate of soda plus 50 pounds dried blood is equivalent to 160 pounds nitrate of soda.
**280 pounds nitrate of soda plus 50 pounds dried blood is equivalent to 320 pounds nitrate of soda.

TABLE I: CROPS GROWN IN CONTINUOUS CULTURE. Yield and increase for 1911 and average annual yield for 18 years 1894-1911

Plot No.	Fertilizing materials — Pounds per acre	1911 Yield — Grain Bus.	1911 Yield — Stover or straw Lbs.	1911 Increase — Grain Bus.	1911 Increase — Stover or straw Lbs.	18 years, 1894-1911 Yield — Grain Bus.	18 years, 1894-1911 Yield — Stover or straw Lbs.	18 years, 1894-1911 Increase — Grain Bus.	18 years, 1894-1911 Increase — Stover or straw Lbs.	Plot No.
	Corn									
1	None	22.11	1,680	.....	.....	21.50	1,443	.....	.....	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160	46.96	2,640	29.05	1,020	41.99	2,330	22 25	952	2
3	" " 60; " " 30; " " 160	35.04	2,280	21.34	720	33.90	1,950	15 91	636	3
4	None	9.50	1,500	.....	.....	16.23	1,249	.....	.....	4
5	Yard manure, 2½ tons	27.58	2,220	18.16	690	27.94	1,774	12.11	538	5
6	" " 5 "	40.29	2,680	30.96	1,120	37.81	2,144	22.37	921	6
7	None	9.25	1,590	.....	.....	15 03	1,210	.....	.....	7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 320	55.61	2,920	47.25	1,473	46.93	2,410	32.89	1,257	8
9	" " 120; " " 60; " " 320	49 28	2,650	41.82	1,347	44.30	2,270	31.25	1,175	9
10	None	6.57	1,160	.....	.....	12 06	1,039	.....	.....	10
	Average unfertilized yield	11.86	1,482	.....	.....	16.21	1,251	.....	.....	
	Oats									
1	None	0.54	387	.....	.....	19 92	771	.....	.....	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160	8.43	1,432	7.32	1,047	40.21	1,886	19 62	1,083	2
3	" " 55; " " 50; " " 160	8.75	1,302	7.06	918	36 66	1,638	15.40	805	3
4	None	2 26	382	.....	.....	21.92	865	.....	.....	4
5	Yard manure, 2½ tons	6.63	965	3.64	535	29 77	1,230	7.62	333	5
6	" " 5 "	9.84	2,010	6.12	1,533	37.07	1,771	14.70	842	6
7	None	4 45	525	.....	.....	22.62	961	.....	.....	7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 320	16 40	2,502	12.24	1,968	46.35	2,452	23.39	1,489	8
9	" " 110; " " 100, " " 320	13 97	2,222	10 09	1,679	44 66	2,322	21.39	1,358	9
10	None	3.59	552	.....	.....	23 60	967	.....	.....	10
	Average unfertilized yield	2 71	461	...	...	22.30	896	.....	.....	
	Wheat									
1	None	1 58	405	.....	.....	7.79	1,091	.....	.....	1
2	Acid phos., 160; mur. potash, 100; nit. soda, 120; dried blood, 50	14.67	1,750	12.59	1,345	19 97	2,539	12.02	1,485	2
3	" " 45; " " 30; " " 120; " " 50	7.91	945	5.33	540	15 73	1,891	7.63	875	3
4	None	3.08	405	.....	.....	8.26	979	.....	.....	4
5	Yard manure, 2½ tons	11.17	1,270	8.26	838	14 00	1,745	5 77	756	5
6	" " 5 "	16.12	1,682	13.37	1,224	18.24	2,268	10.03	1,270	6
7	None	2.58	485	.....	.....	8 18	1,008	.....	.....	7
8	Acid phos., 160; mur. potash, 100; nit. soda, 280; dried blood, 50	19.83	2,060	17 47	1,618	22 99	2,935	15.11	1,971	8
9	" " 90; " " 60; " " 280; " " 50	15.92	1,655	13.79	1,257	20.84	2,499	13.26	1,581	9
10	None	1.91	355	.....	.....	7.29	873	.....	.....	10
	Average unfertilized yield	2.29	412	.....	.....	7.88	947	.....	.....	

The unfertilized yield on Plot 1 in the corn test is regularly higher than on the similarly treated plots, 4, 7 and 10. The difference this year is somewhat larger than usual, and the average yields on all the corn plots are higher than the average for the previous 5-year period. The oats crop, however, shows lower yields, due to unfavorable seasonal conditions. The wheat crop of 1911 suffered from a combined attack of Hessian fly and joint worm.

TABLE II: CROPS GROWN IN CONTINUOUS CULTURE. Average annual yield and increase per acre by 5-year periods

Plot No.	Grain						Stover or straw						Plot No.
	1894-1898		1899-1903		1904-1908		1894-1898		1899-1903		1904-1908		
	Yield Bus.	Increase Bus.	Yield Bus.	Increase Bus.	Yield Bus.	Increase Bus.	Yield Lbs.	Increase Lbs.	Yield Lbs.	Increase Lbs.	Yield Lbs.	Increase Lbs.	
Corn													
1	29.19	.....	21.85	.....	17.09	.....	1,449	.....	1,234	.....	1,546	.....	1
2	44.61	15.53	47.21	27.03	38.50	24.08	2,076	630	2,202	1,013	2,520	1,394	2
3	38.86	9.88	39.09	20.59	28.00	16.25	1,770	330	1,820	671	2,138	848	3
4	28.86	.....	16.81	.....	9.09	.....	1,436	.....	1,106	.....	1,162	.....	4
5	36.44	8.68	29.21	12.75	23.77	14.75	1,670	278	1,588	497	1,958	773	5
6	43.13	16.49	40.11	24.01	34.62	25.65	1,938	590	1,924	851	2,404	1,195	6
7	25.53	.....	15.74	.....	8.86	.....	1,304	.....	1,060	.....	1,232	.....	7
8	44.43	20.26	52.55	37.85	44.55	36.41	2,008	749	2,376	1,358	2,568	1,415	8
9	42.76	19.96	50.13	36.45	41.73	34.34	1,870	655	2,232	1,256	2,458	1,383	9
10	21.44	.....	12.65	.....	6.64	.....	1,170	.....	934	.....	996	.....	10
	26.26	.....	16.76	.....	10.43	.....	1,339	.....	1,083	.....	1 231	.....	
Oats													
1	26.87	.....	16.75	.....	20.40	.....	892	.....	578	.....	855	.....	1
2	42.22	14.75	40.11	22.39	45.46	24.59	1,697	749	1,701	1,083	2,136	1,279	2
3	38.75	10.67	36.47	17.78	40.79	19.46	1,470	467	1 463	806	1,890	1,037	3
4	28.67	.....	19.66	.....	21.80	.....	1,059	.....	697	.....	855	.....	4
5	30.83	2.40	28.51	8.13	35.03	12.98	1,021	—55	1,030	283	1,565	670	5
6	34.81	6.63	36.76	15.67	44.10	21.83	1,265	173	1,516	720	2,232	1,297	6
7	27.94	.....	21.82	.....	22.55	.....	1,110	.....	846	.....	974	.....	7
8	48.75	20.37	48.87	26.51	47.89	25.17	2,086	971	2,342	1,493	2,675	1,712	8
9	46.94	18.10	47.36	24.46	45.61	22.80	1,982	862	2 131	1,078	2,548	1,601	9
10	29 28	.....	23.43	.....	22.98	.....	1,125	.....	856	.....	936	.....	10
	28.19	.....	20.41	. ...	21.93	.....	1,046	. ..	744	.....	905	.....	
Wheat													
1	10.56	.....	7.86	.....	5.95	.....	1,334	.....	926	.....	1,038	.....	1
2	19.78	9.32	21.90	13.73	17.41	11.21	2,205	967	2,420	1,489	2,701	1,684	2
3	16.33	5.97	16.90	8.42	13.31	6.87	1,720	579	1,644	709	2,158	1,163	3
4	10.26	.....	8.78	.....	6.68	....	1,044	.....	940	.....	973	.....	4
5	13.28	3.13	14.26	5.28	12.23	5.74	1,475	430	1,498	550	1,973	982	5
6	15.77	5.72	18.46	9.28	17.48	11.18	1,743	698	2,014	1,057	2,670	1,663	6
7	9.95	....	9.38	.....	6.11	....	1,045	.....	965	.....	1,025	.....	7
8	20.69	10.87	25.26	16.47	20.88	14.80	2,510	1,463	2,724	1,810	3,208	2,239	8
9	19.01	9.33	22.45	14.25	19.12	13.10	2,159	1,110	2,181	1,323	2,846	1,933	9
10	9.55	.....	7.62	.....	6.00	.....	1,051	.....	805	.....	858	.....	10
	10.08	.....	8.41	.....	6.19	.....	1 119	.....	909	.....	973	.....	

THE 5-YEAR ROTATION

In this experiment corn, oats, wheat, clover and timothy are grown in succession on five tracts of land, sections A, B, C, D and E, containing 30 one-tenth acre plots each. Sections A and B of this test lie in Range VIII, south of the areas devoted to continuous cropping, while sections C, D and E occupy Range IX, near the east side of the farm.

The land was underdrained in 1893 and corn was grown that season on section C. The planting was delayed by the draining and the season proved unfavorable, so that the results of that season's work have not been included in the average. In 1894 wheat was harvested on section A, oats on section C and corn on section D. The clover and timothy followed the wheat on section A in 1895 and 1896, and the rotation has since been regularly followed.

Beginning with 1900, lime was applied to the west half of each plot in this rotation, fertilized and unfertilized alike, while the land was being prepared for corn, the lime being applied at the rate of one ton per acre of ground quicklime in 1900, 1901, 1902 and 1903, applied in the spring after plowing, and in the fall of 1903 for the crop of 1904. In 1905 the liming was changed to the east half, a ton of quicklime being used that spring, but in 1906 and 1907 ground limestone was used, at the rate of two tons per acre. No lime was applied in 1908, but since then it has been applied to the west half as at the beginning. The table gives the average yield for the entire plot in each case, averaging the limed and unlimed halves.

In 1895 and 1896, and again in 1899, 1900 and 1901 the wheat in this test was injured by Hessian fly, the yield on the unfertilized land falling to a small fraction over one bushel per acre in 1896 and 1900. The wheat was again injured by Hessian fly in 1911, and also by joint worm.

The clover seeding failed to catch in 1904 and soybeans were grown instead and harvested as hay, the timothy crop of the following year being replaced by German millet. The timothy failed in 1909, as did the millet sown in its place, so that no crop of either was harvested that year.

Diagram II shows the arrangement of plots and plan of fertilizing one of the sections in this experiment, the five sections being arranged and treated exactly alike. Tables III and IV give the yields per acre for 1910 and for the average of the 18 years, and Table V shows the general results by periods.

DIAGRAM II: PLAN OF FERTILIZING IN 5-YEAR ROTATION

Plots one-tenth acre—Fertilizing materials in pounds per acre

Plot No.	On corn			On oats			On wheat			
	Acid phosphate	Muriate of potash	Nitrate of soda	Acid phosphate	Muriate of potash	Nitrate of soda	Acid phosphate	Muriate of potash	Dried blood	Nitrate of soda
1	....	....	....	....	....	.. .	....	....	....	....
2	80	....	....	80	....	....	160	....	....	....
3	....	80	....	....	80	....	....	100	....	....
4	....	....	....	....	....	....	.. .	....	....	....
5	....	....	160	....	....	160	....	....	50	120
6	80	....	160	80	....	160	160	....	50	120
7	....	....	....	....	....	....	....	....	....	....
8	80	80	....	80	80	....	160	100	....	.. .
9	....	80	160	....	80	160	....	100	50	120
10	....	....	....	....	....	....	.. .	....	....	....
11	80	80	160	80	80	160	160	100	50	120
12	80	80	240	80	80	240	160	100	50	200
13	....	....	....	....	....	....	....	....	....	....
14	80	80	160	....	....	....	160	100	50	120
15	....	....	....	....	....	....	160	100	50	120
16	....	....	....	....	....	....	....	....	....	....
17	160	80	80	160	80	80	160	100	25	60
18	Barnyard manure, 8 tons on corn and wheat									
19	....	....	....	....	....	....	....	....	....	....
20	Barnyard manure, 4 tons on corn and wheat									
21	Same elements as 17, but nitrogen in oilmeal									
22	....	....	....	....	....	....	....	....	....	....
23	Same elements as 17, but nitrogen in dried blood									
24	Same elements as 17, but nitrogen in sulphate ammonia									
25	....	...	.. .	....	....	...	....	....	....	...
26	Same elements as 11, but phosphorus in bone meal									
27	Same elements as 11, but phosphorus in dissolved bone black*									
28	....	....	....	....	....	....	....	....	....	....
29	Same elements as 11, but phosphorus in basic slag									
30	Same elements as 17, but nitrogen in tankage									

*Previous to 1910. Since 1910 nitrogen in nitrate of lime and phosphorus in acid phosphate.

TABLE III: CROPS GROWN IN 5-YEAR ROTATION

Yield and increase per per acre, 1911. Total fertilizing elements for one rotation

Plot No.	Fertilizing elements			Corn		Oats		Wheat		Hay		Plot No.
	Nitrogen Lbs.	Phosphorus Lbs.	Potassium Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.	Clover Lbs.	Timothy Lbs.	
				Yield per acre								
1	....	....	....	47.96	2,170	15.39	497	6.58	645	1,244	2,426	1
2	....	20	....	53 35	2,550	26.00	847	12.58	1,215	1,715	2,808	2
3	....	....	108	50.61	2,490	17.58	527	4.96	442	1,092	3,128	3
4	....	....	....	35.89	1,980	14 22	525	4.71	587	1,137	3,057	4
5	76	....	....	44.35	2,220	18.75	670	5.46	412	1,447	2,995	5
6	76	20	....	66.07	2,590	32.65	1,175	17 87	1,597	2,186	3,164	6
7	....	....	....	40.68	2,140	17.26	557	5.54	557	1,119	3,182	7
8	....	20	108	71.18	2,820	33.20	1,207	14.37	1,297	1,733	3,323	8
9	76	....	108	55.82	2,480	19.69	670	9.93	790	1,448	3,315	9
10	....	....	....	40.89	2,070	13.59	455	6.62	612	1,190	2,888	10
11	76	20	108	76.36	2,980	36.79	1,312	22.00	2,240	1,981	2,870	11
12	112	20	108	74.11	3,050	37 03	1,285	22.67	2,240	1,927	2,897	12
13	....	....	....	42.57	2,030	12.50	470	6.12	552	1,040	2,675	13
14	50	15	74	71 96	2,890	26.33	817	19.08	1,905	1,688	2,968	14
15	25	10	41	49.25	2,330	17 89	537	19.62	1,742	1,573	3,128	15
16	....	....	....	37.50	1,960	13 05	452	5 62	472	1,004	3,208	16
17	38	30	108	71.75	2,790	44 92	1,782	22 16	1,980	1,999	3,839	17
18	144	48	112	79.39	3,090	41.95	1,737	27.75	2,425	3,155	4,879	18
19	....	....	....	34.42	1,910	18.52	587	7.50	640	1,191	3,332	19
20	72	24	56	61.89	2,430	32.73	1,242	20.33	1,650	2,595	4,106	20
21	38	30	108	68.25	2,720	37.96	1,325	22.12	2,102	1,965	3,262	21
22	....	....	....	36.61	2,000	12.50	460	7.25	675	1,182	3,110	22
23	38	30	108	74.03	2,900	36.72	1,235	20.79	1,942	2,115	3,457	23
24	38	30	108	77.46	3,030	36.95	1,247	18.12	1,632	2,195	3,795	24
25	....	....	....	41.32	2,080	12.57	417	7.29	702	1,439	3,598	25
26	76	20	108	69.10	2,660	30.08	997	19.17	1,770	2,570	3,386	26
27	76	20	108	68.96	2,690	35.78	1,275	14.50	1,120	2,488	3,190	27
28	....	....	....	49.60	2,070	15.78	465	5.29	552	1,679	3,163	28
29	76	20	108	72.21	2,790	34.76	1,217	18.45	1,482	2,915	3,270	29
30	38	30	108	72.96	2,820	37.73	1,482	18.33	1,520	3,110	3,981	30
Average unfertilized yield.....				40.74	2,041	14.54	488	6.25	599	1,222	3,064	
				Increase per acre								
2	....	20	....	9.41	443	11.00	341	6.62	589	507	166	2
3	....	.. .	108	10.70	447	2.97	11	—.37	—164	—81	281	3
5	76	....	....	6.86	187	3.52	134	.47	—165	316	—104	5
6	76	20	....	26.99	503	16.40	629	12.61	1,030	1,061	—24	6
8	....	20	108	30.43	703	17.26	684	8.47	722	590	239	8
9	76	....	108	15 00	387	4.88	181	3.07	196	282	327	9
11	76	20	108	34.81	923	23.56	852	15.55	1,648	841	53	11
12	112	20	108	32.10	1,007	24.44	820	16.38	1,668	837	151	12
14	50	15	74	31.08	883	13.65	353	13.13	1,380	660	115	14
15	25	10	41	10.06	347	5.02	79	13.83	1,243	557	98	15
17	38	30	108	35.28	847	30 05	1,285	15.91	1,452	933	586	17
18	144	48	112	43.94	1,163	25.25	1,195	20.88	1,841	2,026	1,592	18
20	72	24	56	26.74	490	16.22	697	12.91	998	1,407	848	20
21	38	30	108	32.37	750	23 45	823	14.79	1,439	780	78	21
23	38	30	108	35 85	873	24.30	789	13.53	1,258	847	184	23
24	38	30	108	37.71	977	25.40	816	10.84	939	842	360	24
26	76	20	108	25.02	583	16 44	564	12.55	1,118	1,058	—67	26
27	76	20	108	22.12	623	21 07	826	8.54	518	889	—118	27
29	76	20	108	22.61	720	18.98	752	13.16	930	1,236	107	29
30	38	30	108	23.36	750	21.95	1,017	13.04	968	1,431	818	30

TABLE IV: CROPS GROWN IN 5-YEAR ROTATION

Average annual yield and increase per acre for the 18 years, 1894-1911

Plot No.	Fertilizing elements			Corn		Oats		Wheat		Hay		Plot No.
	Nitrogen Lbs.	Phosphorus Lbs.	Potassium Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.	Clover Lbs.	Timothy Lbs.	
Yield per acre												
1	...	..	...	30.71	1,673	31.82	1,325	10.61	1,134	2,018	2,899	1
2	...	20	...	37.83	1,871	40.00	1,665	18.69	1,870	2,569	3,133	2
3	...	..	108	34.60	1,929	34.52	1,405	12.11	1,285	2,319	2,982	3
4	...	..	...	29.62	1,642	30.74	1,277	10.98	1,123	2,067	2,806	4
5	76	..	..	34 65	1,822	34.79	1,421	12.93	1,426	2,387	3,165	5
6	76	20	...	44.61	1,993	46.06	1,950	24.29	2,495	3,150	3,488	6
7	.	..	...	30 35	1,641	31.00	1,266	10.87	1,126	1,971	2,691	7
8	...	20	108	44.09	2,177	42.96	1,845	19.91	1,894	2,916	3,147	8
9	76	..	108	36 16	1,941	36 72	1,629	13.70	1,463	2,346	3,021	9
10	..	..	...	28.93	1,587	30.81	1,257	10.91	1,093	1,897	2,642	10
11	76	20	108	47.47	2,284	49.23	2,203	27 13	2,891	3,320	3,606	11
12	112	20	108	47.89	2,298	48 65	2,287	27 82	2,960	3,404	3,515	12
13	..	..	...	29.19	1,614	30.86	1,311	10 86	1,113	1,941	2,637	13
14	50	15	74	44.44	2,188	39 03	1,681	25.19	2,651	2,964	3,270	14
15	25	10	41	32.33	1,840	32.36	1,339	24.15	2,492	2,571	2,999	15
16	...	..	...	27.09	1,613	29.26	1,210	9.72	957	1,754	2,552	16
17	38	30	108	44.12	2,260	48.24	2,310	22.92	2,326	3,098	3,329	17
18	144	48	112	49 00	2,460	42.10	1,894	22.24	2,401	3,395	4,099	18
19	...	..	...	30.54	1,715	30.70	1,299	10.68	1,095	1,898	2,674	19
20	72	24	56	43.71	2,178	37 69	1,668	18.34	1,941	2,992	3,541	20
21	38	30	108	46.46	2,255	44 44	2,031	23.96	2,494	2,920	3,147	21
22	...	..	...	27.73	1,662	29.69	1,234	10 26	1,025	1,682	2,416	22
23	38	30	108	46.58	2,264	47.22	2,098	22.82	2,291	2,865	3,140	23
24	38	30	108	47.03	2,288	48.47	2,313	23.33	2,356	3,011	3,098	24
25	...	..	...	30.67	1,743	30.92	1,335	11.17	1,172	1,955	2,741	25
26	76	20	108	45.47	2,304	46 37	2,034	23.88	2,409	3,498	3,707	26
27	76	20	108	47.31	2,313	48.82	2,239	26 20	2,679	3,111	3,526	27
28	...	..	...	32 58	1,800	32 49	1,338	10.94	1,070	2,026	2,923	28
29	76	20	108	47.77	2,402	47 16	2,049	24.88	2,588	3,301	3,852	29
30	38	30	108	47.72	2,261	44.54	1,972	24.64	2,218	3,347	3 819	30
Average unfertilized yield				29.74	1,668	30.83	1,287	10.72	1,093	1,921	2,698	
Increase per acre												
2	...	20	...	7.48	208	8.54	356	7.95	740	534	265	2
3	...	..	108	4.62	277	3.42	112	1.25	159	268	145	3
5	76	..	...	4.79	181	3.96	147	1.99	303	352	397	5
6	76	20	...	11 50	352	15.14	680	13.38	1,370	1,147	759	6
8	...	20	108	14.22	554	12.03	582	9.03	779	970	473	8
9	76	..	108	6.76	336	5.85	369	2.80	359	424	363	9
11	76	20	108	18.46	688	18.40	928	16.25	1,791	1,408	966	11
12	112	20	108	18.78	693	17.82	994	16.95	1,853	1,478	875	12
14	50	15	74	15.96	575	8.70	405	14.71	1,590	1,085	661	14
15	25	10	41	7.61	261	3.57	163	14.05	1,483	756	419	15
17	38	30	108	18.91	649	18.50	1070	12 88	1,323	1,296	736	17
18	144	48	112	22.96	824	11.85	731	11 88	1,352	2,045	1,466	18
20	72	24	56	14.11	480	7 33	391	7.80	868	1,167	953	20
21	38	30	108	17.79	575	17.01	879	13.56	1,446	1,166	645	21
23	38	30	108	17.87	575	17 12	831	12.26	1,217	1,092	616	23
24	38	30	108	17.34	572	17.96	1012	12.46	1,233	1,147	465	24
26	76	20	108	14.16	541	14.93	697	12.78	1,321	1,519	901	26
27	76	20	108	15.37	532	16.85	902	15 18	1,575	1,110	664	27
29	76	20	108	15 19	602	14.67	711	13.93	1,517	1,275	929	29
30	38	30	108	15.14	461	12.05	628	11.69	1,148	1,321	897	30

TABLE V. TOTAL FERTILIZING MATERIALS AND THEIR COST, AND TOTAL AND NET VALUE OF INCREASE PRODUCED FOR 5-YEAR PERIODS AND FOR 18 YEARS, ALL CALCULATED FOR ONE ROTATION OF 5 YEARS

Plot No.	Fertilizing materials in pounds per acre for each rotation	Cost of fertilizers for each rotation	Average value of total increase per acre for each rotation				Net gain or loss (—) from fertilizers for each rotation				Plot No.
			First 5-years	Second 5-years	Third 5-years	18-year average Total	First 5-years	Second 5-years	Third 5-years	18-year average Net	
2	Acid phosphate, 320	$ 2 60	$ 8.50	$ 17.37	$ 24.32	$ 16 53	$ 5.90	$ 14.77	$ 21.72	$ 13.93	2
3	Muriate potash, 260	6.50	5 19	4.67	9.17	6.21	—1.31	—1.83	2 67	—0.29	3
5	Nitrate soda, 440; dried blood, 50	14.40	4.70	10 47	9.30	8.31	—9.70	—4.00	—5.37	—6.09	5
6	Acid phosphate, 320; nitrate soda, 440; dried blood, 50	17 00	19.09	35.27	39.75	30 04	2.09	18.27	22.75	13 04	6
8	Acid phosphate, 320; muriate potash, 260	9.10	14.40	24.37	33.51	24.48	5.30	15 27	24.11	15.38	8
9	Muriate potash, 260; nitrate soda, 440; dried blood, 50	20.90	5 85	11.35	13 23	11.08	—15 05	—9.55	— 6 67	—8 82	9
11	Acid phos., 320; mur. potash, 260; nit. soda, 440; dried blood, 50	23.50	26.40	42 43	49.96	39.14	2.90	18.93	26.46	15 64	11
12	" " 320; " " 260; " " 680; " " 50	30 70	26.16	45.53	48.24	39.71	—4.54	14 83	17.54	9 01	12
14	" " 240; " " 180; " " 280; " " 50	16.05	21.37	32.91	37.33	30.59	5.32	15.86	21.28	14.54	14
15	" " 160; " " 100; " " 120; " " 50	8.60	13.89	22.86	27.13	22.08	5.29	14 26	18 53	13.48	15
17	" " 480; " " 260; " " 220, " " 25	17 60	15.74	36 61	46 28	34 92	—1.86	19.01	28.'8	17.32	17
18	Yard manure, 16 tons	?	19 82	34 24	55.91	39.32	?	?	?	?	18
20	Yard manure, 8 tons	?	13.02	21 28	35.36	25.34	?	?	?	?	20
21	Same elements as 17, but nitrogen in oilmeal	17.60	20.43	36.25	42.24	33.49	2.83	18.65	24 64	15 89	21
23	" " " 17, " " " dried blood	17.60	19.09	34.37	39.28	31.83	1.49	16.77	21 68	14.23	23
24	" " " 17, " " " sulphate ammonia	17 60	20.70	32.77	38.71	31.83	3 10	14.77	21 11	14.23	24
26	" " " 11, " phosphorus in bonemeal	23.50	20.89	36.17	42 55	32.86	—2.61	12.67	19 05	9.36	26
27	" " " 11, " " " dissolved in boneblack*	23.50	19.86	39.88	42.08	33.71	—3.64	16.38	18.58	10 21	27
29	" " " 11, " " " basic slag	23.50	21 91	39 32	39.04	33.56	—1.59	15.82	15.54	10 06	29
30	" " " 17, " nitrogen in tankage	**17.60	13.74	30.51	41.62	30.36	.....	12.90	24 02	12.76	30

The nearest practicable approach to a common denominator for the various kinds of produce grown in this rotation is their market value, and in Table V the results of the test are arranged on this basis for three 5-year periods and for the entire 18 years, corn being rated at 40 cents per bushel, oats at 30 cents, wheat at 80 cents, hay at $8.00 per ton, stover at $3.00 and straw at $2.00; valuations much below present prices for the grains, but not far from the average values during the period of the test.

The fertilizing materials are valued at a fraction over $16.00 per ton for acid phosphate, 2½ cents per pound for muriate of potash and 3 cents per pound for nitrate of soda; and it is assumed that the cost per pound of the fertilizing elements will be practically the same in the other carriers used on Plots 21 to 30, inclusive.

The table shows that the effectiveness of the fertilizers and manure has increased with each successive period, the greatest relative increase being shown by the manure. Taking the second part of the table, giving the net gain after deducting the cost of the fertilizers, it will be seen that during the first period eight of the fertilizer applications failed to produce sufficient increase to cover their cost; during the second period three, and during the third period two. Every complete fertilizer has been used with a profit since the first period, but when either nitrate of soda or muriate of potash has been used unaccompanied by some carrier of phosphorus there has been a loss in each period and in the average of the 18 years.

Nevertheless, both nitrogen and potassium are essential to the highest net profit, as shown by comparing Plot 2, receiving phosphorus only, with Plot 8, receiving potassium in addition, and Plot 11, receiving these with nitrogen.

The results of the comparison of different carriers of nitrogen and phosphorus have been discussed in Circular No. 93.

* Previous to 1910. Since 1910 nitrogen in nitrate of lime and phosphorus in acid phosphate.

** Since first period. Smaller application during first period.

THE POTATOES-WHEAT-CLOVER ROTATION

This experiment is located on the South Farm, southeast of the orchards, and contains three sections of 34 plots each. The south section (A) and about half of the middle section (B) had been in cultivation for an unknown period before the test began. The north part of section B and all of the north section (C) were cleared from the forest for the purposes of this test. The old land was tile drained in 1893, and the work was begun by planting section A to potatoes in 1894. Wheat and clover followed in 1895 and 1896 and the rotation has been maintained regularly since.

The potato crops in this test have in some seasons been somewhat injured by blight, and in 1904 a dashing rain, coming just after the potatoes had been planted, washed much of the seed out of the ground. These difficulties have caused an irregular stand, and for this reason the attempt has been made to correct the yields on the basis of the average stand obtained on the unfertilized plots, but this method has not proved satisfactory and hence the actual yields are given in the table. In 1909 the potatoes were reduced to about one-third the average crop by a combined attack of white grub and Fusarium wilt, the latter causing the larger part of the injury. The crop was severely injured by wilt again in 1910 and considerably injured in 1911.

In 1895 and 1896 the wheat in this test was severely injured by Hessian fly, but it escaped the attack of 1899 to 1901. In 1911 there was again some injury from fly and joint worm.

In 1900 the clover failed; attempts were made to grow crimson clover and soybeans in its stead, but there was failure in securing a stand of these crops also, so that it has been necessary to omit that season from the calculations. In 1905 continuous rains prevented harvesting the clover until very late, and caused the fertilized plots to lodge, so that these plots weighed less than those not fertilized, though earlier in the season they had shown a distinctly stronger growth. As there was no way by which the yields could be corrected and as it seemed desirable to include the crop in the general average because of its effect on the average unfertilized yield it has been so included, although the doing so slightly reduces the apparent average effect from the fertilizers.

Diagram III shows the arrangement of plots and plan of fertilizing one of the sections in this experiment, the three sections being arranged and treated alike. Tables VI and VII give the yield per acre for 1911 and for the 18 years, 1894-1911.

DIAGRAM III: PLAN OF FERTILIZING IN POTATOES-WHEAT-CLOVER ROTATION

PLOTS ONE-TENTH ACRE — Fertilizing materials in pounds per acre

Plot No.	On Potatoes			On Wheat			
	Acid Phosphate	Muriate of potash	Nitrate of soda	Acid Phosphate	Muriate of potash	Dried blood	Nitrate of soda
1	....	....	....	....	....	....	...
2	160	....	....	160	....	...	...
3	....	100	....	....	100	....	....
4	....	....	....	.. .	....	....	....
5	....	....	80	....	....	50	120
6	160	....	80	160	...	50	120
7	....	.. .	....	....	....	....	...
8	160	100	....	160	100	...	....
9	....	100	80	...	100	50	120
10	....	....	....	....	...	....	....
11	160	100	80	160	100	50	120
12	160	100	160	160	100	50	200
13	....	....	....	....	....	....	....
14	320	200	160	160	100	50	120
15	480	300	320	....	....	....	....
16	....	....	....	....	...	....	....
17	....	....	....	Manure, 4 tons on wheat			
18	...	....	....	Manure, 8 tons on wheat			
19	....	....	....	....	...	....	....
20	160	100	80	160	100	25	60
21	Same elements as 20, but nitrogen in oilmeal						
22	....	....	....	....	...	....	...
23	Same elements as 20, but nitrogen in dried blood						
24	Same elements as 20, but nitrogen in sulphate ammonia						
25	....	....	....	....	....	....	....
26	Same elements as 11, but phosphorus in bone meal						
27	Same elements as 11, but phosphorus in dissolved bone black						
28	....	....	....	....	....	....	....
29	Same elements as 11, but phosphorus in basic slag						
30	Manure, 8 tons on potatoes			....	....	....	....
31	....	....	...	....	....	....	....
32	...	....	...	Manure, 16 tons on wheat			
33	Same elements as 20, but nitrogen in tankage						
34	....	....	....	....	....	....	....

CROPS IN 3-YEAR ROTATION OF POTATOES, WHEAT AND CLOVER

TABLE VI: Yield per acre 1911, and average for 18 years, 1894-1911

Fertilizing elements for each rotation

Plot No.	Fertilizing elements			Potatoes		Wheat				Clover		Plot No.
						1911		17-year av.				
	Nitrogen Lbs.	Phosphorus Lbs.	Potassium Lbs.	1911 Bus. (actual)	18-yr. av. Bus.	Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.	1911 Lbs.	16-yr. av. Lbs.	
1	..	..	..	127.00	152.90	29.96	2,464	30.78	3,180	3,959	4,309	1
2	..	20	..	140.00	166.42	37.37	3,457	36.59	3,832	3,531	4,504	2
3	..	..	83	139.82	166.06	29 25	2,545	32.22	3,031	3,753	4,185	3
4	..	..	..	129.03	156.83	28.08	2,335	30.37	2,985	3,706	3,914	4
5	38	..	..	137.18	161.71	27.21	2 707	30.56	3,228	4,523	4,228	5
6	38	20	..	122.06	167.34	36.17	3,490	36.48	3,899	4,729	4,377	6
7	..	..	..	126.13	144.37	27.96	2,362	28.60	2,817	4,534	3,861	7
8	..	20	83	150.65	176.87	38.79	3,472	36.61	3,447	4,249	4,157	8
9	38	..	83	160.62	162.59	27.75	2,575	34.28	3,261	4,586	4,355	9
10	..	..	..	126.38	146.53	25.83	1,950	29 65	2,782	3,609	3,731	10
11	38	20	83	153.25	172.44	37.71	3,417	38.58	3,850	4,889	4,316	11
12	50	20	83	141.12	178.34	37 50	3,430	38.32	3,974	4,569	4,488	12
13	..	..	..	140.42	145.92	24.75	2,015	28.89	2,732	4,249	3,904	13
14	50	30	124	142.66	179 70	38.29	3,909	38 30	3.973	4,977	4,466	14
15	50	30	124	149.42	175.97	39.25	3,625	37.22	3,656	5,333	4,463	15
16	..	..	..	124.75	136 37	24.96	2,042	27.62	2,549	4,373	3,642	16
17	36	12	28	129 00	149 43	32 33	2,700	32.04	3,152	4,978	4,259	17
18	72	24	56	134 96	155.66	33.75	2,875	33.26	3,276	5,297	4,658	18
19	..	..	..	112.08	133.99	20.46	1,512	24.73	2,397	3,822	3,364	19
20	25	20	83	144.92	176.48	36.46	3,232	34.79	3,451	4,497	4,211	20
21	25	20	83	138.58	167.44	32.21	2,727	34.67	3,329	4,320	3,827	21
22	..	..	..	114.33	136.02	19.17	1,450	24.28	2,236	3,626	3,377	22
23	25	20	83	128.92	163.96	35.08	3,155	35.43	3,402	3,626	3,806	23
24	25	20	83	128.08	170.34	36 37	3,017	35.57	3,327	3,893	3,822	24
25	..	..	..	103 83	135.27	18.58	1,705	24.88	2,360	3,324	3,407	25
26	38	20	83	136.75	165.67	31.12	2,332	35 54	3,394	4,089	4,181	26
27	38	20	83	134.83	171.16	33.08	2,835	36.99	3,730	4,035	4,010	27
28	..	..	..	112.25	138.00	17.25	1,205	25.12	2,448	3,680	3,542	28
29	38	20	83	133.25	169.78	32.33	2,980	37.34	3,767	4,871	4,458	29
30	72	24	56	147.33	180.99	30.83	2,510	32.52	3,187	5,013	4,404	30
31	..	..	..	105 83	142.19	17.21	1,527	24.93	2,464	4,213	3,503	31
32	144	48	112	144.68	185.68	36.33	3,460	38.58	3,997	5,582	5,084	32
33	25	20	83	125 33	170.56	33.42	2,935	38.47	3,574	4,071	4,077	33
34	..	..	..	119.92	141.81	20.75	1,515	26.84	2,555	3,466	3,502	34
Average unfertilized yield				120.16	141.94	22.91	1,840	27.03	2 612	3,880	3,678	

TABLE VII. Increase per acre, and annual average for 18 years, 1894-1911

Cost of fertilizer for 1 rotation and 18-year average value of increase for each rotation

Plot No,	Potatoes		Wheat				Clover		Cost of fertilizers	Value of increase for one rotatiion		Plot No.
			1911		17-year av.							
	1911 Bus. (actual)	18-yr. av. Bus.	Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.	1911 Lbs.	15-yr. av. Lbs.		Total	Net	
2	12.32	12.20	8.04	1,037	5.95	716	−344	327	$ 2.60	$11.66	$ 9.06	2
3	11.47	10.53	0.54	168	1.71	−19	−33	139	5.00	6.11	1.11	3
5	9.12	9.03	−0.83	363	0.78	299	541	331	7.20	5.58	−1.62	5
6	−5.04	18.82	8.17	1,137	7.29	1,026	471	498	9.80	13.67	6.58	6
8	24.44	31 78	11.54	1,247	7.66	642	23	339	7.60	20.84	13.24	8
9	34.32	16.78	3.21	488	4.97	467	669	582	12.20	13.48	1.28	9
11	24.19	26.11	12.24	1,445	9.18	1,085	1,067	527	14.80	20.98	6.18	11
12	6.38	32.25	12.39	1,437	9.18	1,225	533	642	19.60	24.04	4.44	12
14	7.46	36.96	13.47	1,878	9.84	1,302	687	650	21.00	26.55	5.55	14
15	19.45	36.42	14.36	1,592	9.18	1,046	1,001	733	21.00	25.82	4.82	15
17	4.22	15.26	8.87	835	5.37	654	789	710	?	13.89	?	17
18	18.66	22.38	11.79	1,186	7.56	828	1,291	1,202	?	20.64	?	18
20	14.09	41.28	16.43	1,741	10.21	1,109	740	842	12.40	29.10	16.70	20
21	25.00	32.09	12 61	1,256	10.24	1,039	629	454	12.40	23.88	11.48	21
23	18.09	28.15	16.11	1,620	10 95	1,126	101	419	12.40	22.82	10.42	23
24	20.75	35 37	17.59	1,397	11.88	1,008	468	425	12.40	26.36	13.96	24
26	30.11	29.49	12.95	794	10.57	1,005	646	729	14.80	24.17	9.37	26
27	25.39	34.09	15.42	1,463	11.95	1,311	474	513	14.80	26.56	11.76	27
29	23.14	30.22	15.09	1,668	12.28	1,314	1,013	928	14.80	26.94	12,14	29
30	39 36	40.19	13.61	1,090	7.53	728	978	886	?	26.37	?	30
32	34.15	44.21	17.94	1,937	11.33	1,335	1,618	1,581	?	34.40	?	32
33	10.11	31.17	13.85	1,416	11.42	965	356	575	12.40	25.87	13.47	33

BARNYARD MANURE TEST

COMPARISON OF YARD WITH FRESH MANURE
THE REINFORCEMENT OF MANURE

This experiment was begun in 1897 for the purpose of comparing manure which has lain for some months in an open barnyard with that taken directly from the stable to the field, and of studying the effect of treating the manure with several absorbent or reinforcing materials. In the earlier years of this investigation a lot of manure was taken from the open barnyard, where it had been accumulating during the winter, and divided into four parcels. With one parcel was mixed the finely ground, phosphatic rock, known as floats, from which acid phosphate is made by mixing it with sulphuric acid; with another parcel acid phosphate was mixed; with a third, the crude potash salt, known as kainit, and with a fourth, land plaster or gypsum; the reinforcing materials being used at the uniform rate of 40 pounds per ton of manure. At the same time manure taken from box stalls, where it had accumulated under the feet of animals kept continuously in their stalls, was divided into similar parcels and treated with like quantities ot the same materials.

After a few weeks the manure thus treated, together with two lots of untreated manure, one taken from the yard and one from the stable, was spread upon clover sod at the rate of eight tons per acre and plowed under for corn, the corn being followed by wheat and clover in a 3-year rotation. During the first three seasons soybeans were grown, because of clover failure, and were plowed under.

Because of the uncertainty as to the quantity of fresh manure required to produce a ton of yard manure under these conditions the plan was changed in 1903 and since then a sufficient quantity of fresh manure for the purpose of the experiment is weighed out of the stables in December or January and forked over carefully to secure a uniform product. The manure is then divided into five equal parcels, four of which are treated as above indicated, and the fifth is left untreated. Each parcel is then divided into two equal portions, one of which is immediately spread upon the plots receiving "stall manure," while the other s placed in a flat, compact pile in an open yard where it remains undisturbed until April, when it is spread on the "yard manure" plots, and the whole is plowed under at the rate of 8 tons per acre of the original manure.

Three tracts of land, A, B and C, are included in the test, each crop being grown every season. The arrangement of these tracts and the plan of fertilizing are shown in Diagram IV, and the results are given in Tables VIII and IX.

DIAGRAM IV: ARRANGEMENT OF PLOTS AND PLAN OF FERTILIZING IN EXPERIMENTS WITH MANURE

PLOTS ONE-SIXTEENTH ACRE

11	Nothing		Nothing	1
12	Yard manure and gypsum		Yard manure and floats	2
13	Stall manure and gypsum		Stall manure and floats	3
14	Nothing		Nothing	4
15	Yard manure, untreated	SECTION A	Yard manure and acid phos.	5
16	Stall manure, untreated		Stall manure ahd acid phos.	6
17	Nothing		Nothing	7
18	Chemical fertilizer		Yard manure and kainit	8
19	Chemical fertilizer		Stall manure and kainit	9
20	Nothing		Nothing	10
11	Nothing		Nothing	1
12	Yard manure and gypsum		Yard manure and floats	2
13	Stall manure and gypsum		Stall manure and floats	3
14	Nothing		Nothing	4
15	Yard manure, untreated	SECTION B	Yard manure and acid phos.	5
16	Stall manure, untreated		Stall manure and acid phos.	6
17	Nothing		Nothing	7
18	Chemical fertilizer		Yard manure and kainit	8
19	Chemical fertilizer		Stall manure and kainit	9
20	Nothing		Nothing	10
11	Nothing		Nothing	1
12	Yard manure and gypsum		Yard manure and floats	2
13	Stall manure and gypsum		Stall manure and floats	3
14	Nothing		Nothing	4
15	Yard manure, untreated	SECTION C	Yard manure and acid phos.	5
16	Stall manure, untreated		Stall manure and acid phos.	6
17	Nothing		Nothing	7
18	Chemical fertilizer		Yard manure and kainit	8
19	Chemical fertilizer		Stall manure and kainit	9
20	Nothing		Nothing	10

NORTH

TABLE VIII: BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION

Average yield per acre 1911 and 15 years 1897-1911

Plot No.	Manure and treatment	1911				Clover	15 years, 1897-1911					Plot No.
		Corn, Sec. B		Wheat, Sec. C			Corn 11* crops		Wheat 11 crops		Hay	
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Sec. A Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	11 crops Lbs.	
		Yield per acre										
1	None	55.09	3,200	8 07	780	3,740	37.92	2,300	12.58	1,516	2,911	1
2	Yard manure and floats	89 65	5,216	19 07	1,784	5,176	60.78	3,427	21.94	2,695	4,291	2
3	Stall manure and floats	93 43	5,120	21 73	1,704	5,233	64 39	3,668	26 50	2,876	4,824	3
4	None	47 03	2,800	6.07	388	4,124	31 48	2,055	10 99	1,283	2,315	4
5	Yard manure and acid phosphate	91 49	4,672	21.20	1,672	5,276	61 94	3,352	25 72	2,737	4,163	5
6	Stall manure and acid phosphate	90 34	4,512	23.60	2,104	5,476	65 62	3,518	26 54	2,918	4,829	6
7	None	41.49	2,208	5.13	460	4,182	30 89	1,986	9 85	1,198	2,301	7
8	Yard manure and kainit	77 20	4,416	14.40	1,232	4,664	55.51	3,258	21.31	2,393	3,520	8
9	Stall manure and kainit	78.74	4,224	14 47	1,228	4,931	60.39	3,513	22 89	2,672	4,280	9
10	None	58 69	3,008	3 93	484	3 598	33.54	2,050	10.36	1,259	2,489	10
11	None	53 60	2,784	12 40	1,064	4,366	37.83	2,382	13 80	1,672	3,182	11
12	Yard manure and gypsum	81.54	4,064	23 87	2,104	5,162	59.48	3,418	24.38	2,712	3,825	12
13	Stall manure and gypsum	85 89	4,000	25 40	2,188	5,390	61 53	3,564	24 19	2,677	3,887	13
14	None	50.11	2,688	9.00	836	4,352	31 95	2,051	10.00	1,223	2,364	14
15	Yard manure, untreated	77.26	3,968	21.60	1,728	5,290	52 53	2,952	20 20	2,222	3,263	15
16	Stall manure, untreated	82.51	4,000	22 60	2,004	5,816	59 46	3,369	21.70	2,413	3,955	16
17	None	63.66	2,976	8.13	632	4,878	37.86	2,373	10 95	1,326	2,659	17
18	Chemical fertilizer†	69 60	3,520	18.13	1,616	4,792	45 07	2,677	14.95	1,711	3,166	18
19	Chemical fertilizer‡	69.60	3,232	10.00	776	5,362	45 02	2,514	15.20	1,804	3,377	19
20	None	50.60	2,528	7.07	728	4,038	31 08	2,047	10.40	1,303	2,738	20
	Average unfertilized yield	52 66	2,774	7.47	671	3,396	34.44	2,155	11.16	1,323	2,435	

* Excluding crop of 1909, which was so injured by grub worms that no comparison is possible.

† Acid phosphate, 80 lbs.; muriate of potash, 80 lbs.; nitrate of soda, 160 lbs.

‡ Acid phosphate, 80 lbs.; muriate of potash, 10 lbs.; tankage (7-30), 100 lbs.

TABLE IX:BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION

Average annual increase and its value (excluding corn crop of 1909)

Plot No.	Manure and Treatment	Average annual increase per acre					Cost of treatment per acre	Value of increase *	
		Corn 14 crops		Wheat 14 crops		Hay 11 crops		Total per acre for one rotation	Net per ton of manure
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Lbs.			
2	Yard manure and floats	25.02	1,209	12.89	1,257	1,578	$1.40	$29.69	$3.54
3	Stall manure and floats	30 77	1,551	14.97	1,516	2,311	1.40	37.34	4.49
5	Yard manure and acid phos.	30.66	1,320	15.10	1,482	1,853	2 40	35.21	4 10
6	Stall manure and acid phos.	34 53	1,539	16.31	1,692	2,523	2.40	40.95	4.82
8	Yard manure and kainit	23.73	1,251	11.29	1,175	1,156	2.70	26.19	2.93
9	Stall manure and kainit	27.73	1,514	12.71	1,434	1,853	2.70	32.37	3.71
12	Yard manure and gypsum	23.61	1,146	11.66	1,190	916	1.00	25.35	3.04
13	Stall manure and gypsum	27.62	1,402	12.52	1,304	1,251	1.00	29.48	3.56
15	Yard manure untreated	18 61	793	9.49	965	801	....	20.39	2.55
16	Stall manure untreated	23.57	1,103	10.88	1,121	1,395	....	26 48	3.31
18	Chemical fertilizer[1]	8 47	412	4.18	393	480	7.45	9 65	.. .
19	Chemical fertilizer[2]	9.68	358	4.62	493	665	2.30	11 26	....

[1]Acid phosphate, 80 lbs; muriate of potash, 80 lbs; nitrate of soda, 160 lbs.
[2]Acid phosphate, 80 lbs; muriate of potash, 10 lbs; tankage, (7-30) 100 lbs.
*See page 105 for valuations.

In all these experiments the increase has been computed on the assumption that changes in the natural fertility of the soil are likely to be progressive; that is, that if the yields of Plots 1 and 4, unfertilized, were 30 and 33 bushels, respectively, those of Plots 2 and 3 would probably have been 31 and 32 bushels, had no fertilizers been applied. As a rule the outcome of the work has justified this assumption, but in the manure test the yields of Plots 1 and 11, Section C, have been so much larger than those of the other unfertilized plots of the series that the question has been raised whether these plots (which are continuous) may not have been located on a strip of land—such as an old fence row—which has not been so depleted of its fertility under previous management as that covered by the adjoining plots.

In Table X the average total yields obtained on the plots treated with floats and acid phosphate are arranged by sections:

TABLE X: Average total yields in plots treated with floats and acid phosphate, arranged by sections

Crop and section*		Yard manure		Stall manure	
		With floats	With acid phosphate	With floats	With acid phosphate
Corn, bus:	A	54.85	50.99	57 83	58.21
	B	71.93	74.33	76 00	74.65
	C	54.39	58.31	58.04	62.52
Wheat, bus:	A	22.05	23.22	29.89	24.95
	B	30.47	31.80	31.53	29.67
	C	23 41	23.35	24.07	25.64
Hay, lbs:	A	4,751	4,373	5,255	4,995
	B	3,720	3,836	4,030	4,007
	C	4,437	4,321	5,312	5,703

* The differences in yield of the different sections are chiefly due to seasonal differences, not to variation of soil.

In 10 of the 18 comparisons given in Table X the total yields on the plots treated with acid phosphate have exceeded those on the plots treated with floats. The general average of all the sections is shown below:

AVERAGE TOTAL YIELD PER ACRE

	Corn Bus.	Wheat Bus.	Hay Lbs.
Yard manure and floats	60.78	24.94	4,291
Yard manure and acid phosphate	61.94	25.72	4,163
Stall manure and floats	64 39	26.50	4,825
Stall manure and acid phosphate	65.62	26.54	4,829

LIME AND FLOATS TEST

This experimemt was begun in 1905 in a 3-year rotation of corn, oats and clover, for the purpose of comparing the effect of different forms of lime and of obtaining further experience in the use of untreated phosphate rock.

The land had been under the regular rotative cropping of the farm since its occupation by the Station, and for a considerable period before, and was in good condition. Twelve tons of manure per acre had been plowed under for corn in 1904. Three sections of 26 plots each are included in the test, the plots containing one-twentieth acre each.

For the crops of 1905 Section A (north end) was manured at the rate of 6 tons per acre only, because of the recent application above mentioned, limed and fertilized and planted in corn. Section B was sown to soybeans instead of clover, the beans to be followed by rye in the fall and corn in 1906. Section C (south end) was limed and fertilized without manure and sown to oats and clover. Thenceforth the manure, lime and fertilizers have all been applied to the corn crops, the manure being plowed under and the lime and fertilizers applied on the surface. The oats and clover receive no treatment.

The clover seeding failed in 1906, 1908 and 1909, and soybeans were grown instead and harvested as hay. As the soybean suffers less from lack of lime than clover the result has been a smaller apparent effect from the lime than might otherwise have been found.

The plan of treatment and average results of the work for the first seven years are given in Table XI.

The 7-year average yield of the unmanured and unfertilized land in this experiment has been 58 bushels of corn, 48 bushels of oats and 2⅓ tons of hay per acre. Over such yields the increase from treatment would be expected to be relatively small. It appears, however, that the further applications of manure are being made with profit, and that the supplementing of manure with lime is further increasing the yield. When preceded by manure, ground limestone on Plot 6 is apparently producing a greater total and net gain than an equivalent quantity of caustic lime on Plot 3 or of hydrated lime on Plot 8. When used in the absence of manure, however, caustic lime is followed by a larger total and net gain on Plot 14 than ground limestone on Plot 15.

While the yield on the land receiving 1000 pounds of floats, applied to the surface after the manure has been plowed under, is greater than that on the land similarly treated with gypsum, in neither case is the effect at all comparable with that observed in the barnyard manure test, previously reported, in which one-third this quantity of these materials is mixed with the manure before application. Nor is the effect on clover of either floats or gypsum equal to that of lime or ground limestone.

When used in the absence of manure as a direct application to the land, 320 pounds of floats has produced a much smaller net gain than the same quantity of acid phosphate costing twice as much, as shown in the triplicate comparison of Plots 17 and 18, 20 and 23, and 21 and 24.

So far, therefore, as the results of this experiment may be accepted, they support other experiments of this Station in showing that ground limestone should be used only as a supplement to liberal manuring or fertilizing, and floats only as a reinforcement of manure, and that neither should be regarded as a substitute for manure or fertilizers.

TABLE XI: CROPS GROWN IN 3-YEAR ROTATION UNDER TREATMENT WITH MANURE, LIME AND FLOATS

Average yield and increase for 7 years, 1905-1911 inclusive

Plot No.	Treatment (Lime, manure, etc., per acre, applied to corn only)	Yield per acre					Increase per acre					Total value of increase	Cost of lime and fertilizers	Net gain or loss (−) per acre	Gain per ton of manure	Plot No.
		Corn, 7 years		Oats, 7 years		Hay 6 yrs. Lbs.	Corn		Oats		Hay 6 yrs. Lbs.					
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.						
1	None	58.49	3,111	45.56	2,513	4,797	.....	...	...	....	....	.....	..	....	....	1
2	Caustic lime, 500 lbs.; manure, 8 tons	72 17	3,751	53.23	2,682	5,387	13.59	606	6.33	229	555	$10.69	$1 50	$9.19	$1.15	2
3	Caustic lime, 1,000 lbs.; manure, 8 tons	74 06	3,829	53.44	2,684	5,581	15.39	647	5.21	290	714	11.83	3.00	8.83	1 10	3
4	None	58 76	3,217	49 57	2,333	4,902	.....	...	....	....	....	.....	..	....	....	4
5	Caustic lime, 2 000 lbs.; manure 8 tons	76.12	4,014	54.99	2,757	6,153	16 49	785	5 32	439	1,182	14.52	6.00	8 52	1.06	5
6	Ground limestone, 1780 lbs.; manure, 8 tons	75.99	3,906	55.65	2,716	5,892	15.50	664	5.88	410	811	13 60	2.70	10 90	1 36	6
7	None	61 36	3,251	48 97	2,292	5,110	.....	...	....	....	....	.....	..	....	....	7
8	Air slaked lime, 1,780 lbs.; manure, 8 tons	75 16	4,026	55 91	2,834	5,902	14.02	797	6.87	577	901	12.03	5.30	6 73	0.84	8
9	Hydrated lime, 1,320 lbs.; manure, 8 tons	75 09	4,009	55 37	2,802	5,792	14 18	896	7.16	581	901	13.21	4 00	9.21	1.15	9
10	None	60 69	3,177	47.39	2,186	4,783	.....	...	....	....	....	.....	..	....	....	10
11	Gypsum, 1,000 lbs.; manure, 8 tons	70 64	3,669	54.24	2,424	4,888	11 07	535	6 54	280	211	8.31	3.00	5 31	0 66	11
12	Floats, 1,000 lbs.; manure, 8 tons	71.17	3,703	55.76	2,541	5,107	12.72	613	7 74	440	536	10.91	4.50	6 41	0.80	12
13	None	57.33	3,016	48.34	2,059	4,465	.....	...	....	....	....	.....	..	....	....	13
14	Caustic lime, 1,000 lbs.	63.64	3,514	49.97	2,241	4,880	6 48	457	1.54	198	456	5.75	3.00	2 75	....	14
15	Ground limestone, 1,780 lbs.	60.76	3,140	47.86	2,046	4,665	3.76	71	−0 66	20	281	2.55	2 70	−0.15	....	15
16	None	56.82	3,080	48.61	2,010	4,343	.....	...	....	....	....	.....	....	..	..	16
17	Caustic lime, 1,000 lbs.; acid phos., 320 lbs.; muriate potash, 40 lbs.	73.06	3,766	52.79	2,225	5,378	15.34	663	4.20	195	943	12.35	6.60	5.75	....	17
18	Caustic lime, 1,000 lbs.; floats, 320 lbs.; muriate potash, 40 lbs.	70 87	4,703	50.78	2,106	5,339	12 26	577	2.21	57	811	9 73	5.45	4.28	....	18
19	None	59.51	3,149	48 55	2,069	4,621	.....	...	....	....	....	.....	....	....	....	19
20	Acid phosphate, 320 lbs.	66 48	3,380	49.17	2,078	4,957	7.16	264	0.90	33	296	4.74	2.60	2.14	....	20
21	Acid phos., 320 lbs.; mur. of potash, 40 lbs.	69 87	3,617	50.94	2,207	5,119	10.73	535	2.96	186	457	7.99	3.60	4 39	....	21
22	None	58 95	3,049	47.70	1,996	4,682	.....	...	....	....	....	.....	....	....	....	22
23	Floats, 320 lbs.	60.76	3,057	48.23	2,011	4,609	3.11	55	1.09	30	35	1.82	1 45	0.37	....	23
24	Floats, 320 lbs.; muriate of potash, 40 lbs.	63 38	3,331	47.25	1,962	4,416	7.04	376	0.66	−3	−51	3.37	2.45	0.92	....	24
25	None	55.02	2,909	46 02	1,950	4,359	.....	...	....	....	....	.....	....	....	....	25
26	Manure, 8 tons since 1909*	61.45	3,320	48.24	2,013	4,570	6.44	411	2.21	63	211	4.76	3.85	0.91	....	26
	Average unfertilized yield	58.55	3,110	47.96	2,156	4,673										

Previously, floats, 320 lbs.; muriate potash, 40 lbs.; dried blood, 100 lbs.

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